High resolution topography along the October 16, 1999 Hector Mine earthquake (Mw7.1) surface ruptures using Airborne Laser Swath Mapping (ALSM)

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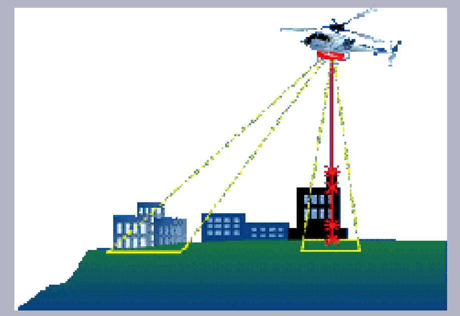
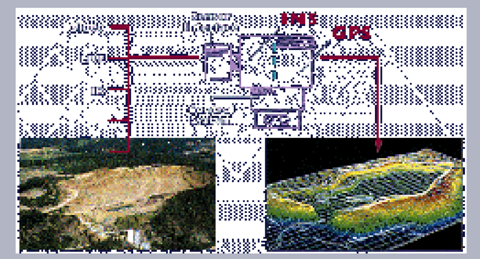


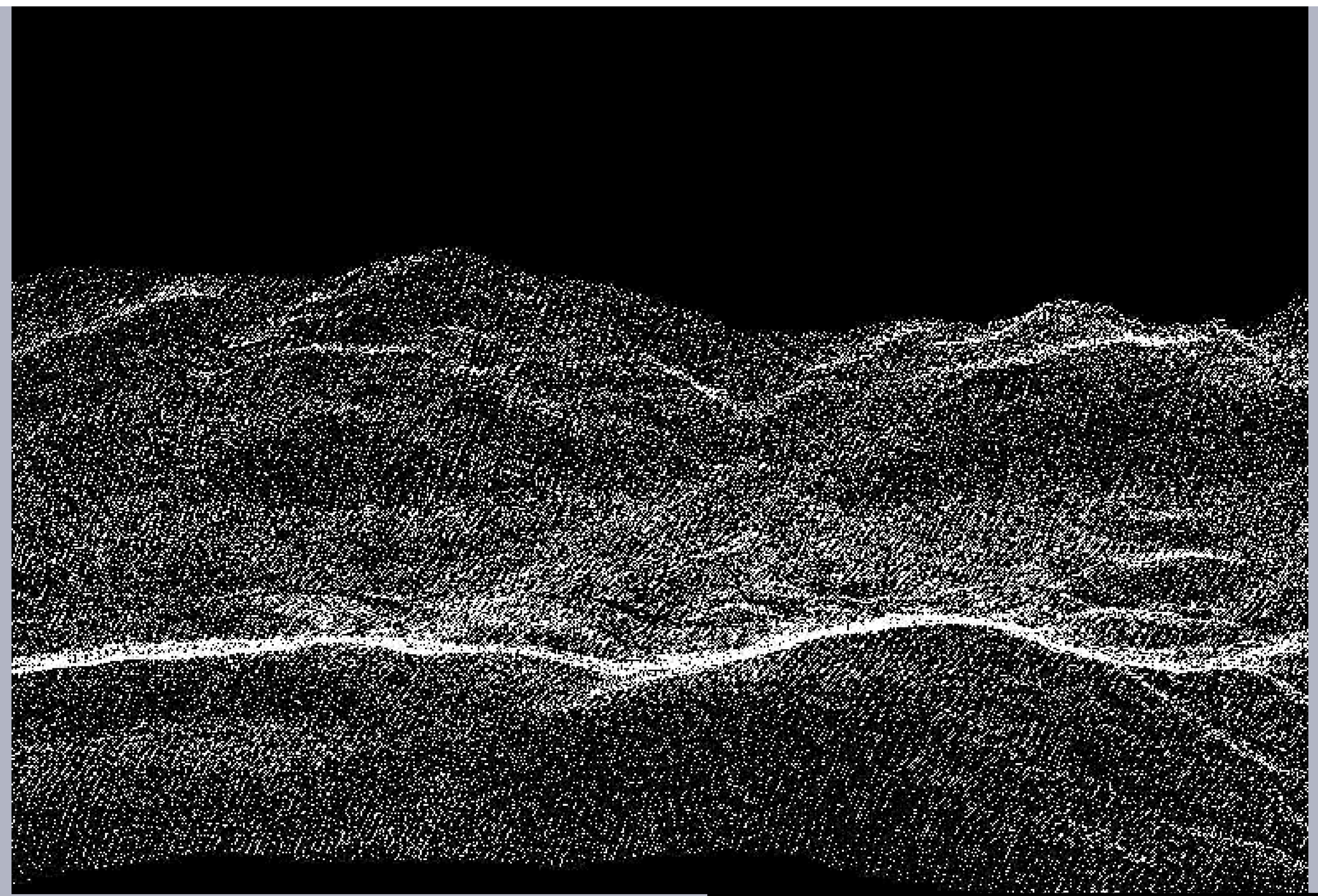
The Hector Mine earthquake produced extensive surface ruptures along more than 70 km of breaks that offset geomorphic features by up to 5.25 meters. Across the surface of the Lavic Lake playa, slip in the range of 2.0 - 3.0 meters displaced the formerly quasi-planar lake bed surface along the fault zone into remarkable geomorphic expressions of compressional and dilatational jogs and steps. In order to document the surface rupture, in particular the maximum slip area and the deformed surface of Lavic Lake, we acquired a high resolution topographic data set. A raster laser scan of the main surface breaks along the entire rupture zone, as well as along an upruptured portion of the Bullion fault, was performed. Airborne Laser Swath Mapping (ALSM), also known as Light Detection and Ranging (LIDAR) and by other names such as simply laser scanning, is becoming an increasingly precise and commercially available topographic mapping method.

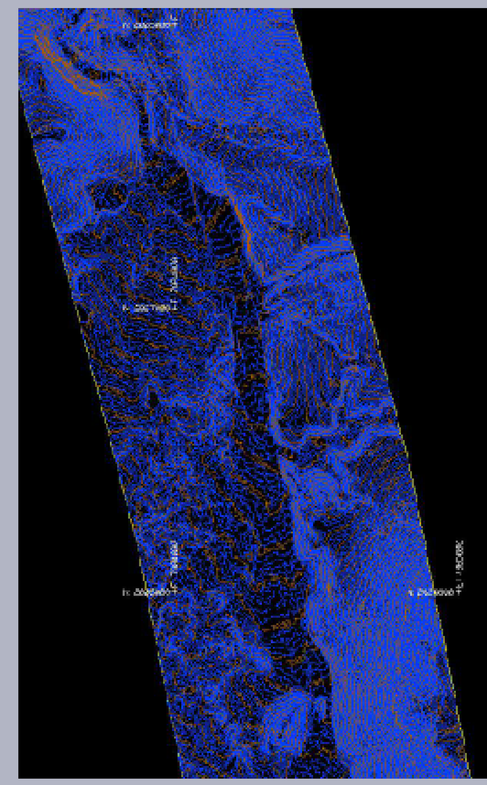
On April 19, 2000, the field team acquired the data set using a helicopter based instrument platform. Ground control was supplied by remotely and sequentially setting several of the Southern California Integrated GPS Network (SCIGN) continuously operating GPS stations to record at high (up to 2 Hz) sampling rate during the flight segments. On-board GPS and an integrated inertial navigation system allowed very precise positioning of the platform and its scanning system optics; the laser scanned at a rate of 7,000 pps. Precise ground waypoint navigation was provided by the surface rupture mapping by Kendrick et al. (USGS Open-File Report, in press). A swath width of 150 meters on average, along over 70 km of fault lines, was obtained in a single day. Along the maximum slip area and Lavic Lake, a swath width of 300 meters was obtained in overlapping, multiple data passes. Calibration maneuvers were performed to assess instrumentation and software unknowns and error sources. As well, a fault-perpendicular swath was run across Lavic Lake to attempt to detect longer wavelength deformation of the dry lake bed. We also collected redundant data over an open pit mine that had previously been mapped in great detail using conventional photogrammetric methods. This will allow both a comparison with other methods, and an assessment of the geodetic capabilies attainable by repeat passes that are separated temporally. We also expect to be able to use these data to estimate slip distribution along the fault, and compare this result with measurements made by other methods (e.g., field mapping, seismological, and geodetic), despite the lack of pre-earthquake high resolution topographic data in this case.

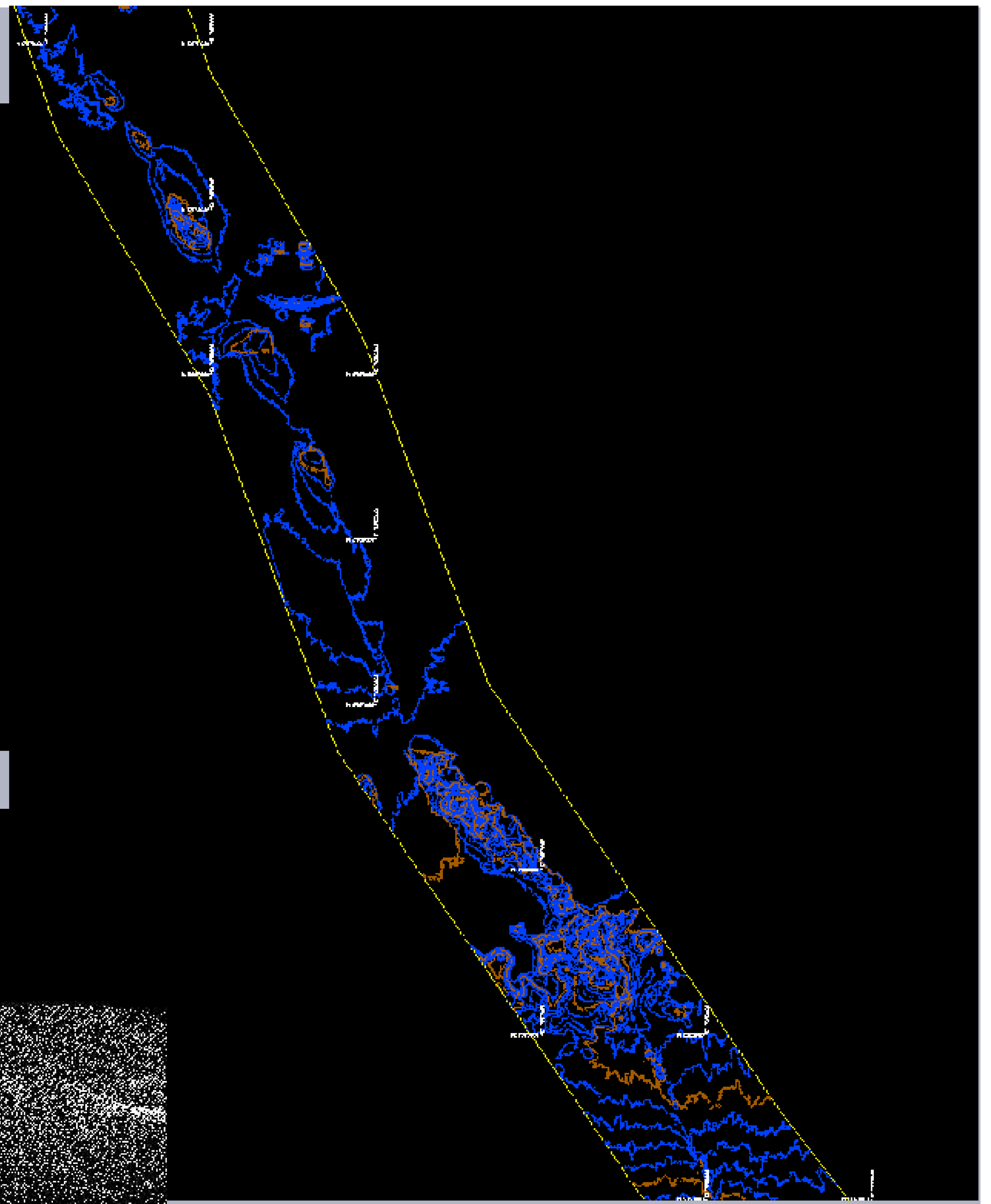
Laser scanning practice is becoming sufficiently precise that repeat-pass use should allow differential positioning at the centimeter level in both horizontal and vertical components (with some spatial averaging) to be obtained after future earthquakes, as long as pre-earthquake data are obtained with which to form a difference image. Within discussions on the scope of the Plate Boundary Observatory, it has been proposed that systemmatic topographic mapping of all active faults within the region of interest should be made in order to improve over the digital elevation models available currently from the USGS, or soon to be from the Shuttle Radar Topographic Mission. One possible method for obtaining such data is laser scanning, although radar and other methods will be considered as well. Our results show that laser scanning can be done cost-effectively, in combination with other imaging, to very high level of detail if desired.

For post-earthquake damage assessment, we suggest that at the same time as such strip mapping along active faults is performed, major lifelines that cross these faults should also be scanned. This would facilitate post-earthquake damage assessment and disaster recovery efforts, through the implementation of the same rapid pre- and post-earthquake differencing methods.

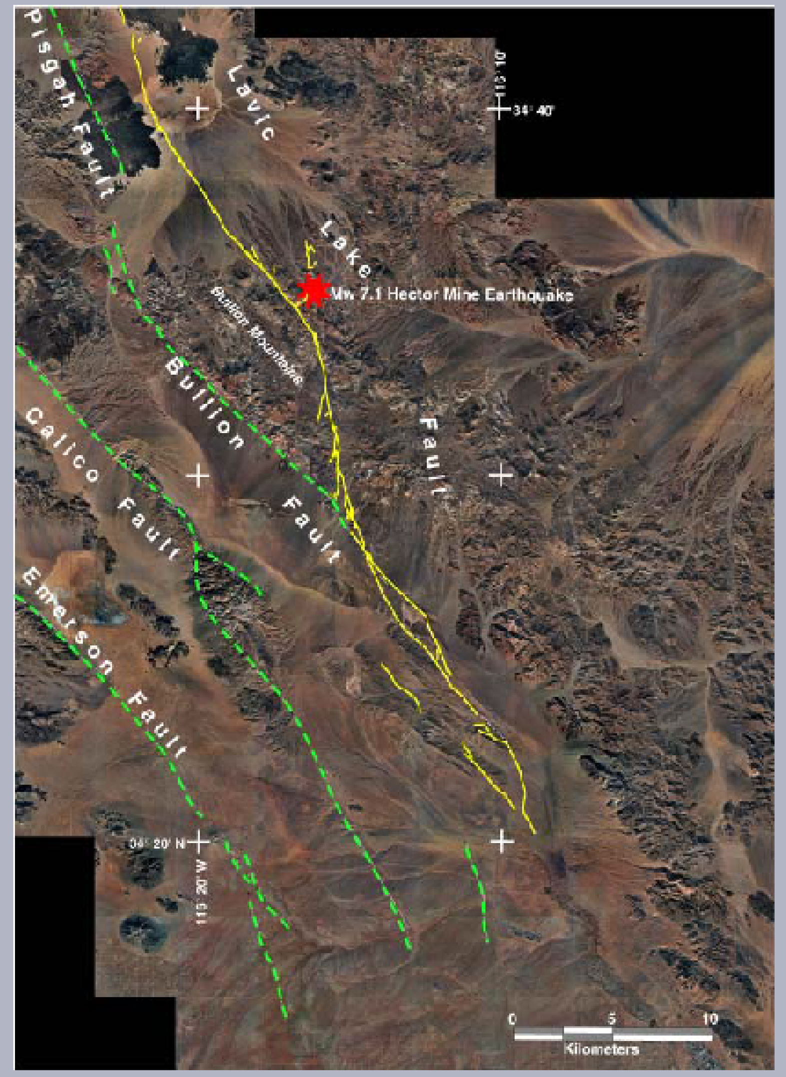


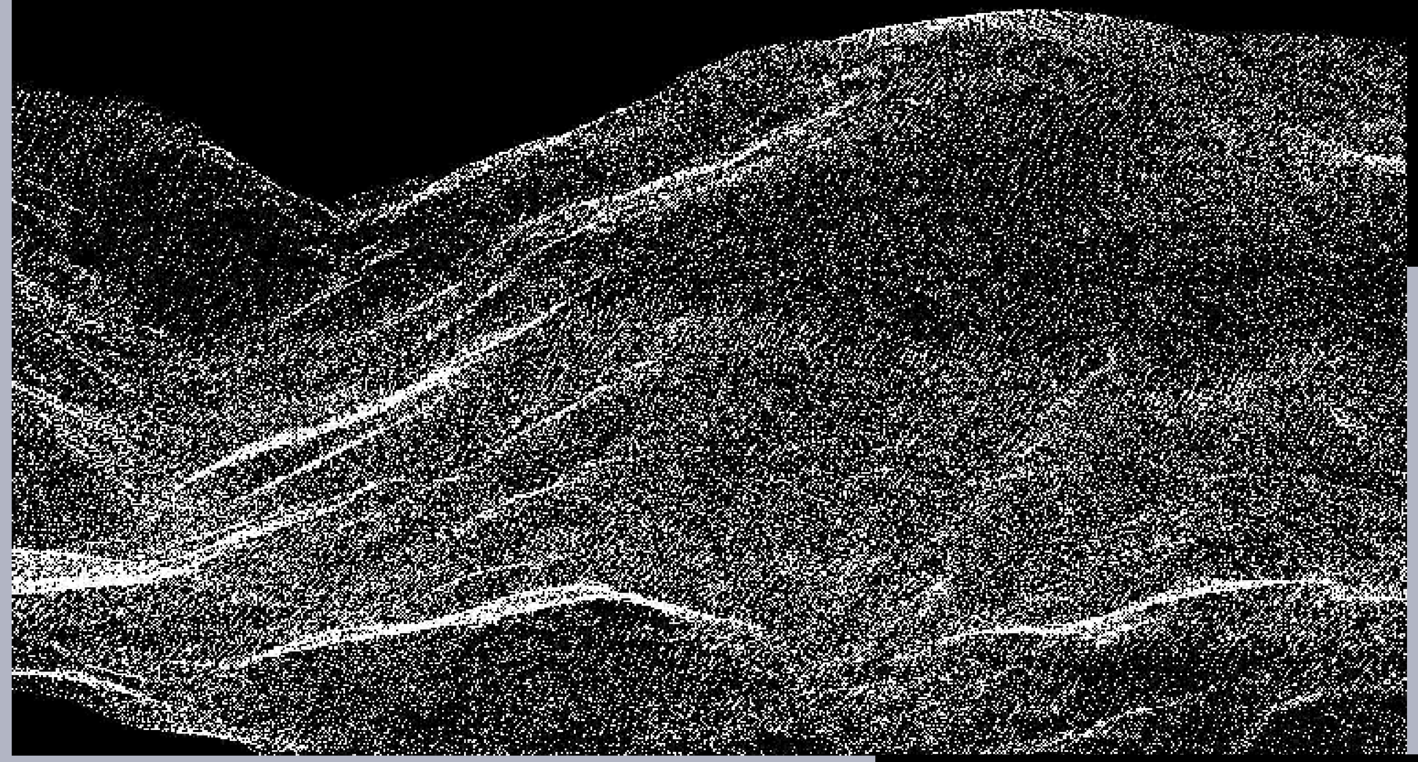




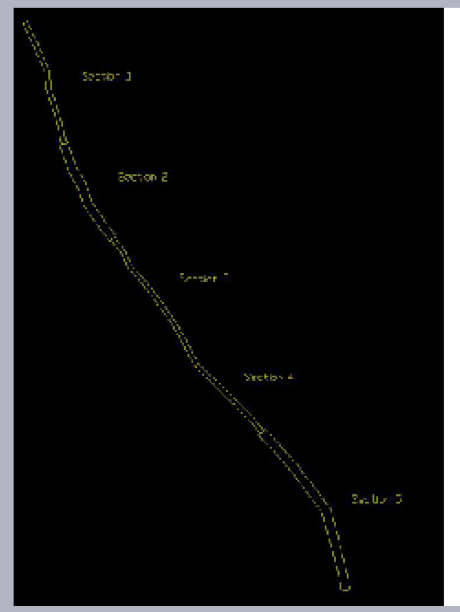


Laser scan data and digital air photos were collected along 70 km of the surface rupture and Bullion fault





Flight lines were defined based on field surface rupture mapping by Kendrick et al. (USGS Open-File Report, in preparation). With a swath width of 150 m, the flight line control was an extreme logistical challenge. On-board GPS navigation made this possible.

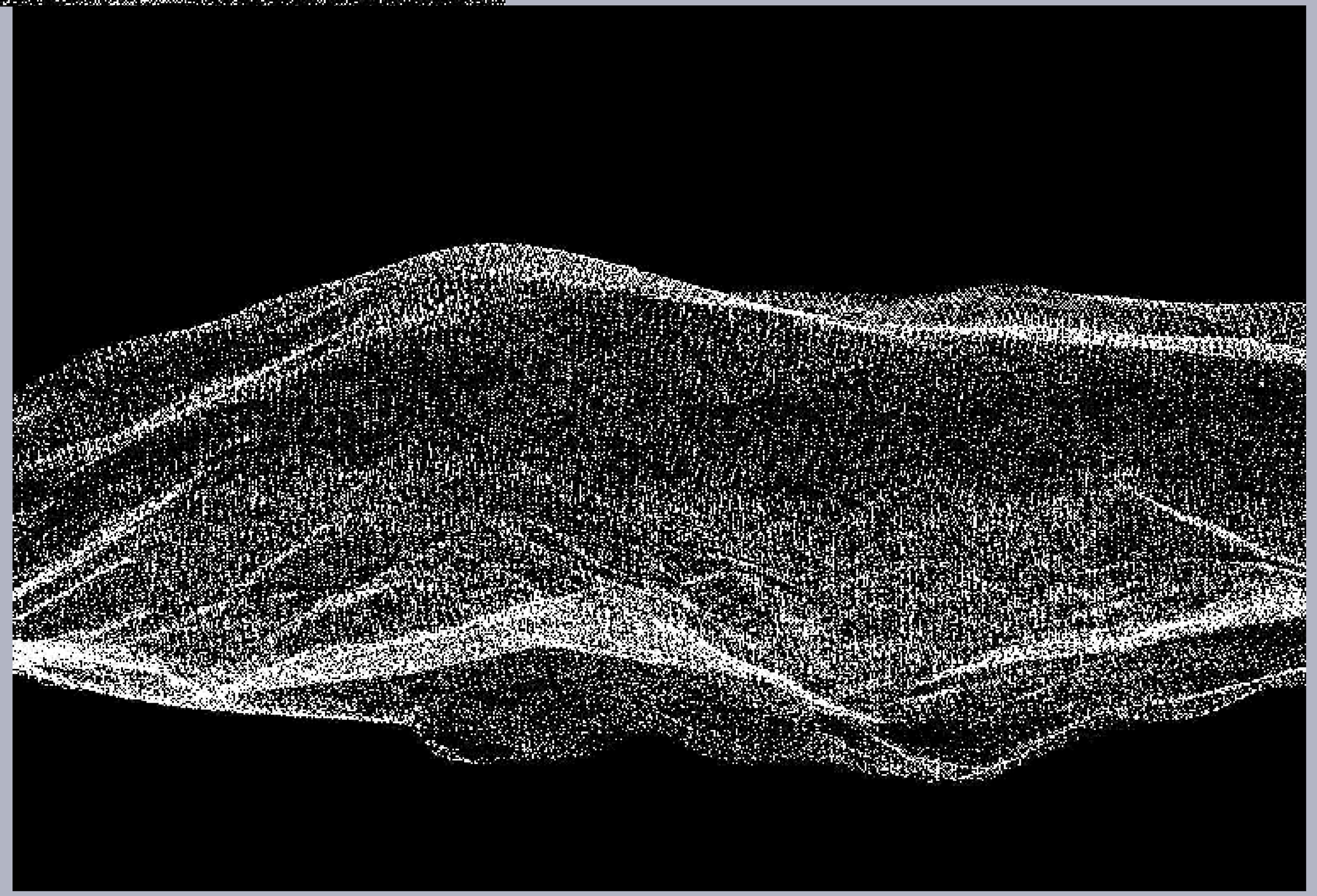


Topography data - at least four points per square meter with relative accuracy of a few centimeters

Laser swath mapping can be used for pre-earthquake mapping of active faults, and then differenced with post-earthquake repeat imagery.

Together with air photos and modern field mapping this method will allow us to quantify surface ruptures in ways that have never been possible before.

Not only for faulting research, for lifelines and infrastructure, as well, this method allows damage assessment of engineered infrastructure such as powerlines, etc.



In order to obtain all of the original data, maps, and additional information about the data set, and preprint of BSSA article, please go to

http://rincon.gps.caltech.edu